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Comparative Cost-Benefit Analysis of Precast Versus Conventional Masonry Construction

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Abstract: ***Selecting the optimal construction method is critical for balancing financial efficiency and project timelines in civil engineering. This study compares the cost-effectiveness of conventional masonry versus precast concrete construction through a mixed-method approach: an explanatory literature review and an exploratory budget comparison based on updated data from a real-world project, including modeling of costs and execution schedules using Excel. Results indicate that precast construction offers superior time efficiency; however, stage-specific cost variations necessitate a granular analysis to determine the overall optimal choice. These findings provide practical guidance for project managers and decision-makers in selecting construction systems that align with project-specific financial and temporal constraints.***

Keywords: Conventional masonry, Precast construction, Budget comparison, Construction time.

1. Introduction

The construction industry has evolved over time according to the physical and financial needs in this highly competitive sector, which has contributed to changes in construction methods as techniques, materials, and tools have also developed through different phases. However, the Brazilian Institute of Geography and Statistics (2019) showed that despite the range of options available for use in a building, conventional masonry is predominantly used in Brazil, both nationally and regionally.

Considering the fact that this system is mostly used in the country, as indicated by the high percentages mainly in the Central-West, Southeast, and Northeast regions, the question arises: does traditional masonry actually outperform the other method to be analyzed, precast construction? Among the two types of construction addressed, prefabricated buildings are used in greater proportions in countries around the world than in Brazil. This information is confirmed by a study conducted by Mordor Intelligence (2023), a company that carries out industrial research and consulting, which shows that this structural method accounts for 20% of the sector in the USA, whereas in Brazil this model does not even appear in the IBGE data mentioned earlier.

Following the evolution of the construction industry, it is important to emphasize, in agreement with Silva, Gomes, Bahiense, Oliveira, and Alexandre (2022), that the sector's development has treated the search for materials with lower environmental impacts as a fundamental issue, especially regarding the reuse of waste, which also has effects in the financial sphere by enabling a good cost-benefit ratio. Therefore, the search for more viable construction alternatives has grown in light of the already established methods.

According to Caporrino (2018), masonry is defined as sets integrated by smaller units, applied one above another horizontally and connected by a binding material or not. Still according to the author, non-structural masonry, also known as partition or traditional masonry, has the main function of separating spaces, in addition to resisting various conditions such as fire, its own weight, variable occupancy loads, wind action, and impact levels that may be caused by local use.

The main component of traditional masonry is blocks, which can be ceramic, concrete, or other materials, as stated by Caporrino (2018). The first type is the model used in the construction of the present work and is defined, according to ABNT NBR 15270:2023, as an element of this construction method that has prismatic holes passing through the faces in which they are included and whose sole function is to resist the weight of the masonry (Associação Brasileira de Normas Técnicas, 2023).

In addition to partition masonry, another method used in Brazil is precast construction, which is normatively defined as "molded beforehand and outside the location of the structure's final use" (Associação Brasileira de Normas Técnicas, 2017, p. 4). For this purpose, still according to ABNT NBR 9062:2017, the manufacturing of these structures must follow strict quality control, evidenced by the analysis conducted after the production of the pieces, where a qualified professional performs the conformity assessment that accompanies the documentation of the project in question. Another inherent factor of this detailed inspection of the element, according to the aforementioned standard, is the requirement to collect samples for analysis of physical aspects such as color, relief, and rebars (Associação Brasileira de Normas Técnicas, 2017).

Precast concrete construction is generally carried out using two systems, according to Lúcia (2023). The first is called the skeleton system and is characterized by the use of columns and beams manufactured elsewhere and brought to the construction site only for assembly; thus, the partition part can be executed using various systems, ensuring greater versatility and adaptability to possible application changes. The other form of construction involves the use of structural panels, which provide internal and external enclosures through precast elements. It is important to note that the present work analyzes the project executed by combining the two methods.

The comparison of the two construction methods can be made based on the budget, a fundamental part of the planning of any construction, as it allows for cost estimation and, according to Cardoso (2020), is a document that requires credibility as it reflects management control tools. The author also explains that the budget must be accompanied by a spreadsheet presenting direct and indirect costs systematically, ensuring the breakdown of the construction into several stages that facilitate visualization and handling by the engineer. To elaborate these spreadsheets, it is necessary to compose the unit cost, given according to the unit of measurement of the service or material, and which is provided by the updated tables of the National System for Research on Construction Costs and Indices (SINAPI) and the System for Residential Costs and Budgets (SICOR).

The investigation of the characteristics and properties of construction methods, which include costs, construction time, sustainability, and efficiency, is essential for choosing the methodology that best fits the building context, since according to the ideas of Araújo and Oliveira (2021), each technique has specific attributes that may or may not offer advantages depending on the region, climate, and availability of specialized labor and materials.

The final objective of the work is to compare the total costs of the residential project, identifying the construction method that offers greater savings and financial efficiency, by seeking to conduct a literature review on conventional and precast masonry systems and collect detailed budgetary data from two companies (one specializing in precast and another in masonry), including materials, labor, and execution time. When exceeding the budget, the present study also aims to compare the construction period and the costs of the construction stages of the two methods, ensuring better visualization of expenses and time in each phase, to allow the choice to be based not only on a system as a whole but also considering that it can be mixed, thus combining different methods.

The choice of topic is justified by the growing demand for efficient and economically viable construction methods in the social housing sector. Evidence of this is the analysis conducted by Mordor Intelligence (2023), which projects the prefabricated building market in Brazil to reach US$3.25 billion in 2024 and a 5.54% higher value projected for the next 5 years, until 2029, reaching US$4.26 billion. The comparison between conventional masonry and precast reinforced concrete is relevant because it provides practical and budgetary support for civil construction professionals and companies seeking to optimize costs without interfering with construction quality, enabling them to make the best choice between the techniques to be used in a building, considering economic analysis, execution schedule, and other factors such as sustainability and structural efficiency. The target audience of this project includes civil engineers, builders, developers, and investors in the social housing market, who will benefit from the detailed cost analysis of the methods. Although there are previous studies on construction methods, the approach focuses exclusively on the budget of a single project, comparing data from companies specialized in precast and masonry, which gives originality to the work. This practical foundation focused on budget analysis contributes to the academic field and the market, offering a direct and applicable study on the economic viability of these systems. The work provides theoretical contributions by offering a comparative and well-founded cost analysis, and practical contributions by providing secure support for decision-making in social housing projects, highlighting the most economical method.

2. Methodology

This topic describes the procedures adopted throughout the research for its development, as well as presents the classification of the entire research, including regarding data collection that ensured quantitative grounding.

With an understanding of the methodological framework, it is possible to classify the work into 4 aspects defined by Gerhardt and Silveira (2009): regarding approach, nature, objectives, and methods.

When discussing the research approach, it seeks to present data that, when analyzed, assist in the correct choice of construction method. According to Prodanov and Freitas (2013), this classification is called applied, as it is characterized by adding knowledge that can lead to the solution of real problems and decision-making.

Considering its nature, the present study is classified as quantitative, as it seeks conclusions through the analysis of numerical data—in this case, budgetary and project data—which, as described by Lozada and Nunes (2018), are raw and objective values taken from previously conducted research.

In accordance with the explanations provided by Prodanov and Freitas (2013), regarding the classification of research by its objective, it can be considered exploratory in that it collects budgetary and construction time data and seeks to interpret them with the aim of creating hypotheses for the use of each construction method. According to the same authors, the study can also be classified as explanatory, as it seeks to demonstrate the causes that justify the time and financial costs in the two types of construction.

Finally, in terms of methods, the research can be described as a literature review, documentary research, and case study. Prodanov and Freitas (2013) define that the first should be used when the study is based on already published materials, such as the theoretical framework on the topic. Furthermore, they define the second classification as one that uses information sources that have not yet been analyzed; thus, it applies here since the work uses projects, budget tables, and construction times that have not been examined. Lastly, the case study is indicated by the authors when data are collected and analyzed to study the subject in depth within its context.

That said, the data collection and analysis process can be described as follows. The present work was carried out by obtaining project information (architectural, structural, electrical, and plumbing) and budget data from Pedro Fonseca Engenharia e Construtora, the company responsible for the construction to be analyzed in Dores do Indaiá/MG. The objective was to secure quantitative data that would later be compared with information on the execution of the same construction using precast concrete. The chosen construction represents similar works carried out in the country and worldwide, as it uses commonly employed materials and techniques and includes the conventional masonry construction system, which accounts for a significant percentage of houses in Brazil.

Additionally, the Liu do Pré-Moldado company was essential for obtaining real budgetary data, which accurately represents the values found in the sector in the study region, as it is located in Quartel Geral/MG, an inland city situated 26 km from Dores do Indaiá/MG. Therefore, the company provided precise data on transportation and material costs, as well as exemplifying the precast construction method.

With this initial information, it is possible to define the research universe, which corresponds to constructions executed using conventional masonry with a reinforced concrete structure and those built with precast concrete. For the first type, the construction in Dores do Indaiá/MG already executed by Pedro Fonseca Engenharia e Construtora is used. Additionally, for the precast sample, the same construction is budgeted using this construction method.

Thus, the work was developed following the phases listed below:

a) first phase: initially, bibliographic and normative research was conducted in books, articles, standards, course completion works, dissertations, and theses, which provided a theoretical foundation on the subject;

b) second phase: after the study, project information was collected, including architectural, structural, electrical, and plumbing designs, made available in DWG format via AutoCAD by the company, which provided the quantities of materials requested by the construction, including hardware and concrete, as well as the dimensions that enabled the calculation of budget spreadsheets and execution times, being made available in Excel;

c) third phase: since the construction began 4 years ago, it was necessary to update the budget tables with current data for subsequent comparison with the other construction method. For this, the SICOR and SINAPI tables were used, which provided updated price estimates for materials and services, and these were added to the Excel spreadsheet taking into account the unit of measurement of each item, its quantity, and its cost;

d) fourth phase: for the budget comparison, tables were constructed considering precast concrete as the construction method, based on the same project dimensions. For this stage, the precast company provided the transportation costs between the cities of Dores do Indaiá and Quartel Geral/MG through dialogue and notes, which were included in the items of the budget spreadsheet. Additionally, the project assisted in providing the costs of precast parts and labor, included in the general expense. These data were passed on through Excel spreadsheets considering the construction in question;

e) fifth phase: with the quantitative data in hand, a budget and construction time comparison was made between the methods, showing which stages have the highest expenses in each type of construction through graphs and being able to determine the reasons that determined the expenses in each budget. For this, the tool used was again Excel, this time through bar and column graphs, and the S-curve;

f) sixth phase: finally, the technical and quantitative analysis of each method can be proposed for decision-making regarding their use in constructions, based on the study carried out, where the qualitative analysis seeks to add bias to the quantitative data for the choice of the construction system.

In light of the above, it is feasible to summarize the data collection and analysis where information was gathered from a meeting with the masonry construction company, which provided all necessary data. Furthermore, the precast company was responsible for conveying the values of materials, labor, transportation, and services, from a personal meeting, already with the original project. All information was analyzed by comparing budget spreadsheets and graphs with Gantt premises. For this, in addition to observation, Excel was used to formulate spreadsheets that gathered the data succinctly and facilitated comparison between the methods.

3. Results and Discussions

First, it is necessary to characterize the construction and its surroundings to understand the choice. For the case study, a construction located at Rua Mestre Angélica, number 424 in the Rosário neighborhood in the city of Dores do Indaiá/MG was selected, calculated and executed by the company Pedro Fonseca Engenharia e Construtora. The municipality is located in the interior and west-central region of the state of Minas Gerais, 241 km from the capital, Belo Horizonte, and has a territorial area of 1,111.202 km² and a resident population of 12,630 inhabitants according to the 2022 Census (Instituto Brasileiro de Geografia e Estatística, 2023).

The company responsible for the construction, Pedro Fonseca Engenharia e Construtora, was founded on June 5, 2020, and is based in the city of Dores do Indaiá itself, at Rua Rio de Janeiro, nº 130. The construction carried out by the organization began in October 2020 and was completed in January 2022. The choice of the study object occurred because the project was executed using load-bearing masonry and reinforced concrete structure, one of the methods to be compared and the most widely used in Brazil today, as shown in previous studies.

With the project plans and budgets for this construction in hand, a budget update was carried out based on updated data from SICOR and SINAPI, in addition to dividing it into stages, which is essential for better expense analysis. To compare costs, the same construction was budgeted for execution using precast concrete, using real prices from the company Liu do Pré-Moldado in Quartel Geral/MG, a city close to the property in question, which ensured more reliable values for the manufacturing and transportation of components, guaranteeing greater accuracy and reliability in the final estimate.

Initially, information about the construction was collected, such as lot area, built area, photos, spreadsheets, and information linked to the project plans and execution, followed by the preparation of the construction schedule. Thus, architectural, structural, electrical, and plumbing project plans were used to enable the preparation of the cost spreadsheet. The budget spreadsheet developed was divided into items and subitems, according to each stage of the house, from earth movement to construction cleaning for handover.

In a second step, the preparation of the spreadsheets began, which were fundamental for budget development. For its development, the SINAPI and SICOR reference spreadsheets were used, considering a BDI (Indirect Cost Rate) of 20.34%, which includes administrative fees, insurance and warranty, risk, profits, and taxes.

3.1 Budget Spreadsheet - Load-Bearing Masonry

To fill it out, it was necessary to develop calculations for each subitem, with preference given to using the SICOR-MG reference spreadsheet, as it pertains to the state where the construction was executed. Certain items were priced according to the SINAPI spreadsheet due to their absence in the main development spreadsheet (SICOR). As shown in Table 1, which presents items 1 and 2 of the budget spreadsheet:

Table 1: Budget Spreadsheet (items 1 and 2).

LOCAL: R. MESTRE ANGÉLICA, 424- ROSÁRIO				FORMA DE EXECUÇÃO:				
				( ) DIRETA			( )	INDIRETA
REGIÃO/MÊS DE REFERÊNCIA: SINAPI - 07/2024 - SICOR- 07/2024							BDI	20,34%
1	SERVIÇOS PRELIMINARES							R$ 6.491,98
1.1	ED- 16660	SICOR	FORNECIMENTO E COLOCAÇÃO DE PLACA DE OBRA EM CHAPA GALVANIZADA #26, ESP. 0,45 MM, PLOTADA COM ADESIVO VINÍLICO, AFIXADA COM REBITES 4,8X40 MM, EM ESTRUTURA METÁLICA DE METALON 20X20 MM, ESP. 1,25 MM, INCLUSIVE SUPORTE EM EUCALIPTO AUTOCLAVADO PINTADO COM TINTA PVA DUAS (2) DEMÃOS	UNI	1,00	R$ 302,02	R$ 363,45	R$ 363,45
UNI= 1								
1.2	ED-51122	SICOR	REGULARIZAÇÃO E COMPACTAÇÃO DE TERRENO MANUAL COM SOQUETE, EXCLUSIVE DESMATAMENTO, DESTOCAMENTO, LIMPEZA/ROÇADA DO TERRENO	UNI	319,53	R$ 10,04	R$ 12,08	R$ 3.860,60
M2								
1.3	ED-50275	SICOR	LOCAÇÃO TOPOGRÁFICA DE VINTE UM (21) ATÉ CINQUENTA (50) PONTOS REFERENCIAIS, INCLUSIVE ESTACA (PIQUETE) DE MARCAÇÃO CORRIDAS PONTALETADAS A CADA 2,00M, REAPROVEITAMENTO (2X), INCLUSIVE ACOMPANHAMENTO DE EQUIPE TOPOGRÁFICA PARA MARCAÇÃO DE PONTO TOPOGRÁFICO	UNI	30,00	R$ 62,82	R$ 75,60	R$ 2.267,93
30 pontos a se considerar								
2	MOVIMENTAÇÃO DE TERRA							R$ 3.447,81
2.1	ED- 51107	SICOR	ESCAVAÇÃO MANUAL DE VALA COM PROFUNDIDADE MENOR OU IGUAL A 1,30 M. AF_02/2021	M3	7,44	R$ 68,05	R$ 81,89	R$ 609,27
124 .0,2 *0,3 = 7,44 m3								
Base x Largura x Altura								
2.2	101616	SINAPI	PREPARO DE FUNDO DE VALA COM LARGURA MENOR QUE 1,5 M (ACERTO DO SOLO NATURAL). AF_08/2020	M2	24,80	R$ 5,64	R$ 6,79	R$ 168,32
124 .0,2 = 4,91 m3								
Base x Altura								
2.3	ED-51096	SICOR	ATERRO COMPACTADO COM PLACA VIBRATÓRIA	m3	45,60	R$ 48,66	R$ 58,56	R$ 2.670,22
(182,40)*0,25 = 45,60								
Area da Construção x altura do Aterro								

Item 1, subitem 1.1 is essential for any construction, as the placement of a sign is mandatory. Furthermore, soil compaction must be done rigorously to ensure safety and reduce the volume of air contained in it. As for item 2, subitem 2.1 uses the measurement of base x width x height for excavating the beam trench. These data are taken from the Structural project (formwork plan), which shows the dimensions of the ground beam. For subitem 2.2, the base x height dimensions are also taken from the structural project to determine the amount of backfill to be used. For subitem 2.3, the area of the land x height of the embankment was taken.

Continuing, the work related to the foundation includes the preparation of the base, crucial to ensuring the stability of the structure. According to the structural design, the footings in this project will vary depending on the weight they will bear, and may include footings of 75x75cm, 85x85cm, 65x75cm, among others (see annex F). Subsequently, CA-50 steel reinforcements are placed, which may vary according to the load demand on each footing. All these phases are carried out in accordance with strict standards, ensuring the integrity and safety of the building's foundation. In item 3, the structural design and architectural design were mainly used to extract data such as beam sections (structural) and total built area (architectural) for completion in accordance with the SICOR framework.

For the foundation and concrete structure stage, shown in Table 2, subitem 3.7 stands out as it shows the slab, the only element of this construction that has already been completed using the prefabricated method.

Table 2: Budget Spreadsheet (item 3).

3 FOUNDATIONS AND CONCRETE STRUCTURE RS 127,786.66									
3.1	ED-49 810	SICO R	FORMING AND STRIPPING OF PLYWOOD AND TIMBER, REUSE (3X) (FOUNDATION	M2	395,34	R$ 58,5 5	R$	70,46	R$ 27.8 55,29
395.34m² (VALUE TAKEN FROM STRUCTURAL CALCULATION PROGRAM)									
3.2	ED-48 298	SICO R	CUTTING, BENDING AND ASSEMBLY OF CA-50/60 STEEL	KG	2.314,5 0	R$ 11,5 4	R$	13,89	R$ 32.1 42,01
2314.50 kg (VALUE TAKEN FROM STRUCTURAL CALCULATION PROGRAM									
3.3	ED-49 812	SICO R	LEAN CONCRETE FILLER, APPLIED IN CORBEL OR FOOTING BLOCKS,	M3	0,96	R$ 552, 04	R$	664,32	R$ 636, 09
19.15*0.05 = 0.96									
Footing Area x 0.05m									
3.4	ED-49 787	SICO R	SUPPLY OF STRUCTURAL CONCRETE, MIXED ON SITE WITH A CONCRETE MIXER, WITH FCK 25 MPA, INCLUDING PLACING, COMPACTION AND FINISHING (FOUNDATION)	M3	36,76	R$ 735, 07	R$	884,58	R$ 32.5 17,28
36.76m³ (VALUE TAKEN FROM STRUCTURAL CALCULATION PROGRAM)									
3.5	ED-50 174	SICO R	PAINTING WITH ASPHALTIC EMULSION, TWO (2) COATS	M2	77,13	RS 28.12	R$	33,84	R$ 2.61 0,05
(229,80*0,3)+(18,20*0,45)									
Lateral Area of the Girder Beams									

3.6	ED-19 633	SICO R	METAL SHORING FOR REINFORCED CONCRETE SLAB AND BEAM, TYPE "A", HEIGHT FROM (200 TO 310) CM, INCLUDING UNLOADING, ASSEMBLY, DISASSEMBLY AND LOADING.	M2X MÈS	147,00	R$ 18,5 6	R$	22,34	R$ 3.28 3,26
147.00*1									
Construction Area x Number of months of shoring for the structural element									
3.7	ED-50 260	SICO R	PRECAST SLAB, TO BE COVERED, INCLUDING COVERING AND = 4 CM, SC = 300 KG/M², L = 4.00 M	M2	147,00	R$ 162, 48	R$	195,53	R$ 28.7 42,68
VALUE TAKEN FROM CALCULATION PROGRAM = 147 M²									
Construction Area (Taken from the Architectural Design)									

Masonry is the construction phase with the greatest differentiation between the two analyzed methods, as ceramic bricks are used in masonry. In the item present in Table 3, most of the calculation data were obtained from the CypeCAD software, which provided the footage data contained in subitems 4.1, 4.2, and 4.3.

Table 3: Budget Spreadsheet (item 4).

4			ALVENARIA/VEDAÇÕES						R$	60.698,73
4.1	ED-48232	SICOR	ALVENARIA DE VEDAÇÃO COM TIJOLO CERÂMICO FURADO, ESP. 14CM, PARA REVESTIMENTO, INCLUSIVE ARGAMASSA PARA ASSENTAMENTO	M2	380,75	R$ 66,73	R$	80,30	R$	30.574,92
(90,60*3)+(60,47*1,5)+(9,60*1,90) = 209,85										
Área de Parede e Área de Platibanda										
4.2	ED-50732	SICOR	EMBOÇO COM ARGAMASSA, TRAÇO 1:6 (CIMENTO E AREIA), ESP. 20MM, APLICAÇÃO MANUAL, PREPARO MECÂNICO	M2	85,68	R$ 32,97	R$	39,68	R$	3.399,45
(28,56*3) = 85,68										
Área de Azulejos										
4.3	ED-9906	SICOR	VERGA/CONTRAVERGA EM CONCRETO ESTRUTURAL PARA VÃOS DE ACIMA 150CM,	M3	1,63	R$ 2.939,83	R$	3.537,79	R$	5.780,04
54,46 *0,15 *0,2=1,63										
Base x Altura x Largura										
4.4	ED-50730	SICOR	CHAPISCO COM ARGAMASSA, TRAÇO 1:2:3 (CIMENTO, AREIA E PEDRISCO), APLICADO COM COLHER, ESP. 5MM, PREPARO MECÂNICO	M2	419,70	R$ 13,90	R$	16,73	R$	7.020,43
209,85*2 = 419,70										
Área de Alvenaria x 2 faces										
4.5	ED-50761	SICOR	REBOCO COM ARGAMASSA, TRAÇO 1:2:8 (CIMENTO, CAL E AREIA), ESP. 20MM, APLICAÇÃO MANUAL, PREPARO MECÂNICO	M2	334,02	R$ 34,64	R$	41,69	R$	13.923,88
419,70 - 85,68 = 334,02M2										
Área de Chapisco Subtraindo a Área de Emboço										

Moving on to the next stage, which includes the roof of the construction, the calculation basis was taken from the architectural project within the AutoCAD program, with the areas and lengths of the construction where the roof was executed being collected, as shown in Table 4.

Table 4: Budget Spreadsheet (item 5).

5			COBERTURA						R$	47.047,77
5.1	ED-48420	SICOR	COBERTURA EM TELHA CERÂMICA COLONIAL PLANA, 24 UNID/M2	M2	147,00	R$ 109,43	R$	131,69	R$	19.358,15
147,00 m2 (Retirada do Projeto de Arquitetura										
Área da Cobertura										
5.2	ED-48406	SICOR	EMBOÇAMENTO DA ÚLTIMA FIADA DE TELHA CERÂMICA COM ARGAMASSA DE CIMENTO, CAL HIDRATADA E AREIA SEM PENEIRAR, NO TRAÇO 1:2:9	M	28,00	R$ 15,63	R$	18,81	R$	526,66
VALOR RETIRADO DE PROGRAMA AUTOCAD = 28,00 M2										
Comprimento de Calha										
5.3	ED-48407	SICOR	ENGRADAMENTO PARA TELHAS CERÂMICA OU CONCRETO EM MADEIRA PARAJU	M	147,00	R$ 127,70	R$	153,67	R$	22.590,10
VALOR RETIRADO DE PROGRAMA AUTOCAD = 147,00 M2										
Área da Cobertura										
5.4	ED-9066	SICOR	REVESTIMENTO DE GESSO EM TETO, ESP. 5MM, APLICAÇÃO MANUAL (SARRAFAEADO)	M	147,00	R$ 25,85	R$	31,11	R$	4.572,86
VALOR RETIRADO DE PROGRAMA AUTOCAD = 147,00 M2										
Área da Cobertura										

After the development of the roof phase, the electrical part begins. In this stage, the architectural and electrical projects were used for sizing and wire gauge of the construction and the necessary footage. Also essential are the number of outlet boxes, distribution board (QDC), and type of standard with load. The electrical budget is shown in Table 5.

Table 5: Budget Spreadsheet (item 6).

6 ELECTRICAL INSTALLATIONS RS 21.163.91								
6.1	ED-20 579	SICO R	AERIAL POWER ENTRANCE, TYPE B1, CEMIG STANDARD, INSTALLED LOAD UP TO 10KW, TWO-PHASE, WITH UNDERGROUND OUTLET, INCLUDING POLE, METER BOX, CIRCUIT BREAKER, BUSBAR, GROUNDING AND ACCESSORIES	UN	1,00	R$ 2.966 ,14	R$ 3.5 69,45	R$ 3.569,45
TOTAL OF 1 UNIT								
POWER ENTRANCE								
6.2	ED-49 502	SICO R	DISTRIBUTION PANEL FOR 36 MODULES WITH 100 A BUSBAR	UN	1,00	R$ 511,0 5	R$	615.00 R$ 615,00
TOTAL OF 1 UNIT								
Taken from the Electrical Project Symbology								
6.3	ED-15 733	SICO R	SET OF ONE (1) SINGLE SWITCH, CURRENT 10A, VOLTAGE 250V, (10A-250V), WITH 4"X2" PLATE FOR ONE (1) POSITION, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	UN	3,00	R$ 25,87	R$	31,13 R$ 93,40
TOTAL OF 3 UNITS								
Taken from the Electrical Project Symbology								
6.4	ED-15 765	SICO R	SET OF ONE (1) SINGLE SWITCH, CURRENT 10A, VOLTAGE 250V, (10A-250V), WITH 4"X2" PLATE FOR TWO (2) POSITIONS, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	UN	2,00	R$ 40,37	R$	48,58 R$ 97,16
TOTAL OF 2 UNITS								
Taken from the Electrical Project Symbology								
6.5	ED-15 771	SICO R	SET OF ONE (1) SINGLE SWITCH, CURRENT 10A, VOLTAGE 250V, (10A-250V), WITH 4"X2" PLATE FOR THREE (3) POSITIONS, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	UN	1,00	R$ 55,09	R$	66,30 R$ 66,30
TOTAL OF 1 UNIT								
Taken from the Electrical Project Symbology								
6.6	ED-15 748	SICO R	SET OF ONE (1) STANDARD SOCKET, THREE (3) POLES, CURRENT 10A, VOLTAGE 250V, (2P+T/10A-250V), WITH 4"X2" PLATE FOR ONE (1) POSITION, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	UN	27,00	R$ 26,57	R$	31,97 R$ 863,31
TOTAL OF 27 UNITS								
Taken from the Electrical Project Symbology								
6.7	ED-15 789	SICO R	SET OF TWO (2) STANDARD SOCKETS, THREE (3) POLES, CURRENT 10A, VOLTAGE 250V,	UN	7,00	R$ 19,88	R$	23,92 R$ 167,47
TOTAL OF 27 UNITS								

Taken from the Electrical Project Symbology								
6.8	ED-15 743	SICO R	SET OF ONE (1) SINGLE SWITCH, CURRENT 10A, VOLTAGE 250V, (10A-250V) AND ONE (1) STANDARD SOCKET, THREE (3) POLES, CURRENT 10A, VOLTAGE 250V, (2P+T/10A-250V), WITH 4"X2" PLATE FOR TWO (2) POSITIONS, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	M	4,00	R$ 41,87	R$	50,39 R$ 201,55
TOTAL OF 4 UNITS								
Taken from the Electrical Project Symbology								
6.9	ED-48 946	SICO R	FLEXIBLE COPPER CABLE, CLASS 5, LSHF/ATOX TYPE INSULATION, NON-HALOGENATED, FLAME-RETARDANT, THERMOPLASTIC, SINGLE-CORE, CROSS-SECTION 1.5 MM², 70°C, 450/750V	M	300,0 0	RS 2.91	R$	3,50 R$ 1.050,57
TOTAL OF 300m								
6.10	ED-48 951	SICO R	FLEXIBLE COPPER CABLE, CLASS 5, LSHF/ATOX TYPE INSULATION, NON-HALOGENATED, FLAME-RETARDANT, THERMOPLASTIC, SINGLE-CORE, CROSS-SECTION 2.5 MM², 70°C, 450/750V	M	400,0 0	RS 3.99	R$	4,80 R$ 1.920,63
TOTAL OF 400m								
6.11	ED-48 961	SICO R	FLEXIBLE COPPER CABLE, CLASS 5, LSHF/ATOX TYPE INSULATION, NON-HALOGENATED, FLAME-RETARDANT, THERMOPLASTIC, SINGLE-CORE, CROSS-SECTION 6 MM², 70°C, 450/750V	M	100,0 0	RS 7.88	R$	9,48 R$ 948,28
TOTAL OF 100m								
6.12	ED-48 981	SICO R	FLEXIBLE COPPER CABLE CLASS 5, INSULATION TYPE LSHF/ATOX NON-HALOGENATED. FLAME-RETARDANT, THERMOPLASTIC, UNIPOLAR, CROSS-SECTION 35 MM², 70°C, 450/750V	M	100,0 0	RS 39.99	R$	48,12 R$ 4.812,40
TOTAL OF 100m								
6.13	ED-34 473	SICO R	BIPOLAR CIRCUIT BREAKER DIN TYPE, NOMINAL CURRENT 10A, SUPPLY AND INSTALLATION,	UN	3,00	RS 44.61	R$	53,68 R$ 161,05
TOTAL OF 3 UNITS								
6.14	ED-34 460	SICO R	MONOPOLAR CIRCUIT BREAKER DIN TYPE. NOMINAL CURRENT 10A. SUPPLY AND	UN	10,00	R$ 14.79	R$	17.80 R$ 177.98
TOTAL OF 10 UNITS								
6.15	ED-34 477	SICO R	BIPOLAR CIRCUIT BREAKER DIN TYPE, NOMINAL CURRENT 50A, SUPPLY AND INSTALLATION,	UN	1.00	R$ 46,31	R$	55.73 R$ 55.73
TOTAL OF 1 UNIT								
6.16	ED-34 479	SICO R	BIPOLAR CIRCUIT BREAKER DIN TYPE, NOMINAL CURRENT 50A, SUPPLY AND INSTALLATION,	UN	1.00	R$ 47,09	R$	56,67 R$ 56,67
TOTAL OF 1 UNIT								
6.17	ED-34 475	SICO R	BIPOLAR CIRCUIT BREAKER DIN 5KA. 20A	UN	3.00	R$ 42.06	R$	50.62 R$ 151.85
			TOTAL OF 3 UNITS					
6.18	ED-34 474	SICO R	BIPOLAR CIRCUIT BREAKER DIN 5KA. 16A	UN	10.00	R$ 42,09	R$	50,65 R$ 506,51
TOTAL OF 10 UNITS								
6.19	ED-34 477	SICO R	BIPOLAR CIRCUIT BREAKER DIN 5KA. 32A	UN	1,00	R$ 43,35	R$	52,17 R$ 52,17
TOTAL OF 1 UNIT								
6.20	ED-34 472	SICO R	BIPOLAR CIRCUIT BREAKER DIN 5KA. 60A	UN	1.00	RS 58.63	R$	70,56 R$ 70,56
			TOTAL OF 1 UNIT					
6.21	ED-13 345	SICO R	WALL LIGHT ARANDELA TYPE FULL HALF-MOON, DIAMETER 25 CM, FOR ONE (1) LED BULB, POWER 15W, BULB A65, SUPPLY AND INSTALLATION, INCLUDING BASE AND BULB	UN	2,00	R$ 66,57	R$	80,11 R$ 160,22
TOTAL OF 2 UNITS								
6.22	ED-13 338	SICO R	COMMERCIAL WALL LIGHT FLANGED OVERHEAD FULL, FOR TWO (2) LED TUBULAR BULBS 2X18W-OT8. COLOR TEMPERATURE 6500K, SUPPLY AND INSTALLATION, INCLUDING BASE AND BULBS	UN	19,00	R$ 191,5 0	R$	230,45 R$ 4.378,57
TOTAL OF 19 UNITS								
6.23	ED-13 346	SICO R	WALL LIGHT ARANDELA TYPE FULL HALF-MOON, DIAMETER 25 CM, FOR ONE (1) LED BULB. POWER 20W. BULB A70. SUPPLY AND INSTALLATION. INCLUDING BASE AND BULB TOTAL OF 11 UNITS	UN	11,00	R$ 74,57	R$	89.74 R$ 987,11

Subsequently, the data for item 7 of subitems 7.1, 7.2, 7.3, 7.4, and 7.5 were filled in, all with the assistance of the architectural and hydraulic projects, which provide information for the survey of materials used for the full execution of the work. See Table 6.

Table 6: Budget Spreadsheet (item 7).
PLUMBING AND SANITARY INSTALLATIONS

	INSTALLOGENDUTIONSANILATIAN							Guangling 13726025
7.1	ED-5 0105	SICO R	SUPPLY AND INSTALLATION OF RIGID PVC PIPE, SMOOTH SEWAGE COLLECTOR (JEI), DN 100 MM (4"), INCLUDING CONNECTIONS	M	150 ,00	R$ 48, 33	R$ 58,16	R$ 8.724,05
TOTAL OF 150m								
7.2	ED-5 0034	SICO R	SUPPLY AND INSTALLATION OF RIGID PVC PIPE, SEWAGE, PB - NORMAL SERIES, DN 40MM (1.1/2"), INCLUDING CONNECTIONS	M	30, 00	R$ 21, 78	R$ 26,21	R$ 786,30
TOTAL OF 30m								
7.3	ED-5 0022	SICO R	SUPPLY AND INSTALLATION OF WELDABLE RIGID PVC PIPE, COLD WATER, DN 50 MM (1.1/2"), INCLUDING CONNECTIONS	M	100 ,00	R$ 45, 19	R$ 54,38	R$ 5.438,16
TOTAL OF 100m								
7.4	ED-5 0019	SICO R	SUPPLY AND INSTALLATION OF WELDABLE RIGID PVC PIPE, COLD WATER, DN 25 MM (3/4"). INCLUDING CONNECTIONS	M	60, 00	R$ 24, 46	R$ 29,44	R$ 1.766,11
TOTAL OF 60m								
7.5	ED-4 9936	SICO R	POLYETHYLENE WATER TANK, CAPACITY 1,000L, INCLUDING LID, FLOAT VALVE, OVERFLOW PIPE, CLEANING PIPE AND ACCESSORIES, EXCLUDING WATER INLET/OUTLET PIPING	UN	1,0 0	R$ 89 0,48	R$ 1.071 ,60	R$ 1.071,60
TOTAL OF 1 UNIT								

It is essential to emphasize that the plumbing and electrical installation stages are carried out after the plaster has already been applied; thus, in conventional masonry wall construction, cuts are made in the plaster and bricks to allow access for conduits and pipes, which not only generates rework and costs but also results in a greater amount of debris.

As for the development stage of item 8, which consists of sanitary ware and metals, it was necessary to collect data from the architectural project to calculate the unit value and value in m^2 for the metal console, as shown in Table 7.

Table 7: Budget Spreadsheet (item 8).

8	LOUCAS EMETAIS								AS 7,182.50
8.1	ED-50324	SICOR	METAL KITCHEN FAUCET, MOVABLE SPOUT, 1/4 TURN OPENING, CHROME FINISH, WITH AERATOR, COUNTERTOP APPLICATION, INCLUDING FLEXIBLE METAL CONNECTION, SUPPLY AND INSTALLATION	UN	6,00	R$ 164,30	R$	197,72	R$ 1.186,31
TOTAL OF 6 UNITS									
8.2	ED-50296	SICOR	CONVENTIONAL CERAMIC TOILET BOWL (W.C.), WHITE COLOR, INCLUDING FIXING/SEALING ACCESSORIES, SUPPLY, INSTALLATION AND GROUTING, EXCLUDING FLUSH VALVE AND CONNECTION PIPE	UN	2,00	R$ 327,10	R$	393,63	R$ 787,26
TOTAL OF 2 UNITS									
8.3	ED-48345	SICOR	WHITE MARBLE COUNTERTOP, THICKNESS = 3 CM, SUPPORTED BY 20 X 30 MM METALON CONSOLE	M2	5,06	R$ 525,97	R$	632,95	R$ 3.202,74
5.06									
8.4	ED-50278	SICOR	UNDERMOUNT STAINLESS STEEL SINK, AISI 304, KITCHEN SINK APPLICATION (560X330X115MM), QUANTITY 2, MOUNTED ON COUNTERTOP, INCLUDING CHROME-FINISHED METAL DRAIN VALVE, CHROME-FINISHED METAL CUP-TYPE TRAP, SUPPLY AND INSTALLATION	UN	2,00	R$ 489,08	R$	588,56	R$ 1.177,12
TOTAL OF 2 UNITS									
8.5	ED-50279	SICOR	UNDERMOUNT WHITE CERAMIC SINK, OVAL SHAPE, INCLUDING CHROME-FINISHED METAL DRAIN VALVE, CHROME-FINISHED METAL CUP-TYPE TRAP, SUPPLY AND INSTALLATION	UN	2,00	R$ 344,47	R$	414.54	R$ 829,07
TOTAL OF 2 UNITS									

Consequently, in item 9 with subitems 9.1, 9.2, 9.3, and 9.4, focused on the cladding part, internal and external floors, including thresholds, the specific measurements were obtained using AutoCAD software and are shown in Table 8.

Table 8: Budget Spreadsheet (item 9).

9	REVESTIMENTOS - PISOS INTERNOS E EXTERNOS								R$ 40.889,23
9.1	ED-50753	SICOR	REVESTIMENTO COM PORCELANATO APLICADO EM PISO, ACABAMENTO ESMALTADO ACETINADO, AMBIENTE INTERNO/EXTERNO, PADRÃO EXTRA, BORDA RETIFICADA, DIMENSÃO DA PEÇA (45X45CM), ASSENTAMENTO COM ARGAMASSA INDUSTRIALIZADA, INCLUSIVE REJUNTAMENTO	M2	147,00	R$ 146,83	R$	176,70	R$ 25.974,20
147,00 M2									
9.2	ED-50566	SICOR	CONTRAPISO DESEMPENADO COM ARGAMASSA, TRAÇO 1:3 (CIMENTO E AREIA), ESP. 20MM	M2	147,00	R$ 35,74	R$	43,01	R$ 6.322,40
147,00 M2									
9.3	ED-9081	SICOR	REVESTIMENTO COM CERÂMICA APLICADO EM PAREDE, ACABAMENTO ESMALTADO, AMBIENTE INTERNO/EXTERNO, PADRÃO EXTRA, DIMENSÃO DA PEÇA ATÉ 2025 CM2, PEI III, ASSENTAMENTO COM ARGAMASSA INDUSTRIALIZADA, INCLUSIVE REJUNTAMENTO	M2	85,68	R$ 70,63	R$	85,00	R$ 7.282,47
85,68									
9.4	ED-51002	SICOR	SOLEIRA EM MÁRMORE, LARGURA 15 CM, ESPESSURA 2,0 CM. AF_09/2020	M2	3,55	R$ 306,38	R$	368,70	R$ 1.310,17
23,69*0,15									

In the stage shown in Table 9, only the architectural design was used to calculate in m^2 the aluminum windows and galvanized gate, both social and garage, and the unit value of wooden doors used in the construction.

Table 9: Budget Spreadsheet (item 10).

10	ESQUADRIAS								R$ 21.678,97
10.1	ED-29484	SICOR	JANELA EM ALUMÍNIO DE CORRER COM 2 FOLHAS, LINHA 25/SUPREMA, ACABAMENTO ANODIZADO NATURAL, INCLUSIVE PERFIS, VIDRO 4MM E INSTALAÇÃO, EXCLUSIVE FERRAGENS PARA JANELA DE ALUMÍNIO DE CORRER	m2	9,28	R$ 858,61	R$	1.033,25	R$ 9.588,57
TOTAL DE 9,28									
10.2	ED-49602	SICOR	PORTA DE MADEIRA COMPLETA, DIMENSÃO (80X210CM), TIPO DE ABRIR, UMA (1) FOLHA,	U	5,00	R$ 994,19	R$	1.196,41	R$ 5.982,04
TOTAL DE 5 UNIDADES									
10.3	ED-50982	SICOR	PORTÃO EM CHAPA DE AÇO GALVANIZADO, TIPO LAMBRIL, ESP. 1,25MM (GSG-18), EXCLUSIVE CADEADO E PINTURA	m2	12,43	R$ 408,36	R$	491,42	R$ 6.108,36

To fill out and develop item 11 shown in Table 10, some subitems were filled in according to the SINAPI reference spreadsheet. The calculations were extracted from the architectural design using AutoCAD software.

Table 10: Budget Spreadsheet (item 11)

	PAINTS								RS 21.279.83
11.1	ED-50451	SICOR	ACRYLIC PAINT ON WALL, TWO (2) COATS, EXCLUDING ACRYLIC SEALER AND ACRYLIC FILLER/RUNNER (PVA)	m^2	334,02	R$ 16,47	R$	19,82	R$ 6.620,28
PLASTERING AREA									
11.2	ED-50452	SICOR	ACRYLIC PAINT ON CEILING, TWO (2) COATS, EXCLUDING ACRYLIC SEALER AND ACRYLIC FILLER/RUNNER (PVA)	m^2	147,00	R$ 18,11	R$	21,79	R$ 3.203,66
SLAB AREA									
11.3	ED-50476	SICOR	FILLING ON CEILING WITH ACRYLIC FILLER, TWO (2) COATS, INCLUDING SANDING FOR PAINTING	M2	147,00	R$ 36,40	R$	43,80	R$ 6.439,15
SLAB AREA									
11.4	ED-50514	SICOR	PREPARATION FOR FILLING OR PAINTING (LATEX/ACRYLIC) ON WALL, INCLUDING ONE (1) COAT OF ACRYLIC SEALER	M2	199,56	R$ 20,89	R$	25,14	R$ 5.016,74
66,52*3									

Finally, the cleaning for handover of the work is shown in Table 11. The value calculation was taken from AutoCAD using the total built area.

Tabel 11: PlanilhaOrcamentaria (item 12)

12	LIMPEZA FINAL DE OBRA							R$ 1.629,69
12.1	ED-50266	SICOR	LIMPEZA FINAL PARA ENTREGA DA OBRA	M2	184,00	R$ 7,36	R$ 8,86	R$ 1.629,69
VALOR RETIRADO DE PROGRAMA AUTOCAD = 299,90 M2								

With all calculations performed, the final result of the construction budget was R$377,083.81, obtained by summing the expenses of each construction phase involving the execution of masonry walls and reinforced concrete structure. The budget spreadsheet is followed by the construction schedule, in which a Gantt chart is created showing the execution time of each phase.

3.2 Construction Schedule - Gantt Chart

The tool chosen to represent the construction time was an Excel chart with Gantt chart premises, as it allows visualization of the construction planning and monitoring. In this way, it is considered that some phases can be executed simultaneously; however, an order is followed that must not only be respected but also demonstrates that activities are interdependent, meaning one cannot start until another is completed. In this case study, the chart was more precise since the construction has already been completed. It is important to note that the date was not changed, as the budget update does not modify the execution time of the construction, since the methods were not altered. The result is highlighted in Figure 1.

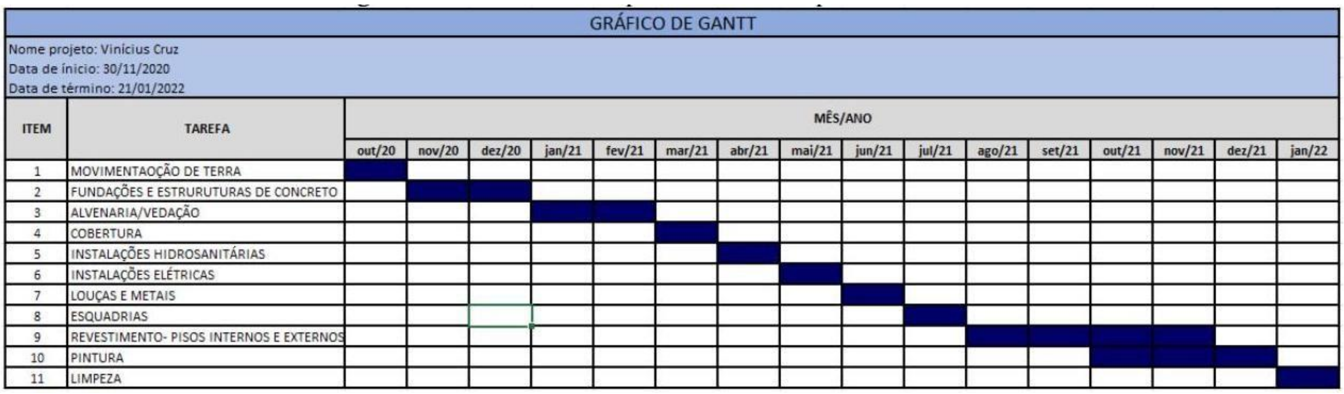

Figure 1: Construction time chart with Gantt premises.

Therefore, it can be seen that the construction was executed over a period of 16 months, with the most time spent on cladding and floors (internal and external), followed by the painting, wall, and concrete structure phases. These 4 phases thus account for 9 months, representing approximately 56% of the total construction time. With the completion of the budget and construction time chart, which are referenced by the masonry wall construction, the case study proceeds to the precast concrete budget and, subsequently, the information will be analyzed according to the S-curve and Excel charts.

3.3 Precast Concrete Construction Budget

For the precast system case study, a budget was requested from Liu do Pré-Moldado company, located in the city of Quartel Geral/MG, 27 km from Dores do Indaiá. The objective was to compare the costs and execution time of a construction using the precast system. The company provided all necessary information on the manufacturing and transportation of components. To assess the costs, phases from the foundation, transportation, and assembly of structural elements such as beams, columns, and slabs were analyzed, following precast standards.

Before preparing the budget, it is necessary to understand the type of material and assembly used by Liu do Pré-Moldado company. This construction method uses structural components manufactured in an industrial unit and transported to the assembly site, where they are positioned and fixed, reducing construction time and labor costs.

This construction system, in addition to saving time and resources, provides standardization and greater quality control of structural elements, contributing to faster and more efficient buildings. An important phase of the construction process using the precast method is the slab execution, where a worker performs activities on the structure composed of precast joists and EPS foam blocks, which serve as filling to reduce the structure's weight.

The presence of a steel mesh over the slab indicates that concreting will be the next step, reinforcing the structure and providing the necessary rigidity. The use of expanded polystyrene blocks, in addition to reducing the self-weight, also offers thermal and acoustic insulation properties. The assembly of the precast slab, together with the rest of the structure, optimizes construction time and reduces the need for large volumes of in-situ concrete.

As in the case of masonry construction, the budgets were organized into items and sub-items, covering everything from earth movement to the completion of the work. For the development of the budget spreadsheet, the SICOR reference tables and composition items were used, which are those manufactured directly at the factory in Quartel Geral, with adjustments to the specific items of the precast system, to ensure greater accuracy with real values.

Preliminary services are essential for a safe and organized execution of the work. Thus, before construction begins, steps such as topographic surveying, which defines the exact position of the work on the land, soil regularization and compaction, necessary to stabilize the construction base, and the installation of signboards are carried out. Items 1 and 2, which refer to preliminary services and earth movement, are shown in Table 12.

Table 12: Precast Budget Spreadsheet (items 1 and 2).

SEICOP JULY 2024 JULY12024			CENTRAL REGION - NO TAX EXEMPTION	BDI=		20.34% EXECUTION REGIME = GLOBAL PRICE (INDIRECT)			
ITEM	REFERENCE	CODE	DESCRIPTION	UNIT	QTY	UNITS/BDI	UNIT PRICE W/BDI	ACCRUED	SUBTOTALS
1			PRELIMINARY SERVICES	R$ 6.491.98					
1.1	SICOR	ED-16660	SUPPLY AND INSTALLATION OF CONSTRUCTION SIGN ON GALVANIZED SHEET #26, 0.45 MM THICK, PRINTED WITH VINYL ADHESIVE, ATTACHED WITH 4.8X40 MM RIVETS, ON 20X20 MM METALON METAL STRUCTURE, 1.25 MM THICK, INCLUDING AUTOCLAVED EUCALYPTUS SUPPORT PAINTED WITH TWO (2) COATS OF PVA PAINT	UNIT	1,00	R$ 302,02	R$ 363,45	R$ 363,45	
1.2	SICOR	ED-51122	MANUAL LAND REGULATION AND COMPACTION WITH SOCKET, EXCLUDING DEFORESTATION, ROOT REMOVAL, LAND CLEANING/HOEING	M2	319,53	R$ 10,04	R$ 12,08	R$ 3.860.60	
1.3	SICOR	ED-50275	TOPOGRAPHIC LOCATION OF TWENTY-ONE (21) TO FIFTY (50) REFERENCE POINTS. INCLUDING STAKES (PEGS) FOR MARKING, DRIVEN AT EVERY 2.00M, REUSE (2X). INCLUDING TOPOGRAPHIC TEAM ASSISTANCE FOR TOPOGRAPHIC POINT MARKING	M2	30,00	R$ 62,82	R$ 75,60	R$ 2.267,93	
2			EARTH MOVEMENT	R$ 3,447.81					
2.1	SICOR	ED-51107	MANUAL TRENCH EXCAVATION WITH DEPTH LESS THAN OR EQUAL TO 1.30 M. AF 02/2021	M3	7.44	R$ 68.05	R$ 81,89	R$ 609,27	
2.2	SINAPI	101616	TRENCH BOTTOM PREPARATION WITH WIDTH LESS THAN 1.5 M (ADJUSTMENT OF NATURAL SOIL). AF 08/2020	M2	24,80	R$ 5,64	R$ 6.79	R$ 168,32	
2.3	SICOR	ED-51096	COMPACTED FILL WITH VIBRATORY PLATE	m3	45.60	R$ 48.66	R$ 58.56	R$ 2.670,22	

Foundation services include the construction of the footing, which is essential to ensure the stability of the structure. The process involves manual excavation of the footing, with lateral disposal of the removed soil, and it is calculated to support the building's loads. Next, CA-60 steel reinforcements are installed in 100x100 mm meshes, which provide additional strength to the concrete. Finally, the plasticized plywood formwork is assembled, which will be reused up to three times to contain the concrete during curing and footing shaping. These steps strictly follow regulatory procedures, ensuring the foundation's integrity and safety. The values for this phase are shown in Table 13.

Table 13: Precast Budget Spreadsheet (item 3).

3			FOUNDATION AND CONCRETE STRUCTURE	R$ 36.350,30					
3.1			FOOTING	R$ 3.539,28					
3.1.1	SICOR	RO-00218	MANUAL TRENCH EXCAVATION IN 1ST CATEGORY MATERIAL AT A DEPTH OF 0 TO 1.50 M	M3	14,18	R$ 66,48	RS 80.00	RS 1,134.43	
3.1.2	SICOR	ED-29582	STEEL MESH REINFORCEMENT CA-60, WELDED TYPE Q-138, DIAMETER Ø4.2MM. MESH WITH DIMENSION (100X100)MM, INCLUDING SPACER, EXCLUDING CONCRETE	m2	23,10	R$ 27,96	RS 33.65	R$ 777,25	
3.1.3	SICOR	ED-49810	FORMING AND STRIPPING OF PLYWOOD AND TIMBER. REUSE (3X) (FOUNDATION)	M2	23.10	R$ 58.55	RS 70.46	RS 1,627.60	

The baldrame beam involves manual excavation and the creation of a lean concrete base, in addition to the installation of CA-60 steel reinforcement, to transfer the structure's loads to the ground. Furthermore, the concrete used is pumped with an FCK of 25 MPa, providing greater strength and durability. The supporting beam, also made with pumped structural concrete and reinforced with CA-60 steel, follows the same control and quality standards. The installation includes the formwork and stripping process, ensuring safety and precision during concrete placement.

The columns are produced in the factory and transported to the construction site, ensuring greater quality control, dimensional accuracy, and strength. The walls are erected using precast concrete panels, manufactured under strict industrial standards. These panels have joints that ensure sealing between connections and structural stability. These steps can be seen in Table 14.

Table 14: Precast Budget Spreadsheet (items 3.2, 3.3, and 4).

3.2 VIGA BALDRAME R$ 13,813.34								
3.2.1	SICOR	RO-00218	MANUAL TRENCH EXCAVATION IN 1ST CATEGORY MATERIAL AT A DEPTH OF 0 TO 1.50 M	M3	14,18	R$ 18,05	R$ 21,72	R$ 308,01
3.2.2	SICOR	ED-49812	LEAN CONCRETE BASE, APPLIED IN CORBEL OR FOOTING BLOCKS. THICKNESS 5 CM. AF 08/2017	M3	0,96	R$ 552,04	R$ 664,32	R$ 636,09
3.2.3	SICOR	ED-29582	CA-60 STEEL MESH REINFORCEMENT, WELDED TYPE Q-138, DIAMETER 04.2MM, MESH WITH DIMENSION (100X100)MM, INCLUDING SPACER, EXCLUDING CONCRETE	M2	94,53	R$ 27,96	R$ 33,65	R$ 3.180,66
3.2.4	SICOR	ED-49787	SUPPLY OF STRUCTURAL CONCRETE, MIXED ON SITE WITH A CONCRETE MIXER, WITH FCK 25 MPA, INCLUDING PLACING, COMPACTION AND FINISHING (FOUNDATION)	M3	9,45	RS 36.76	R$ 44,24	R$ 418,04
3.2.5	SICOR	ED-49810	FORMWORK AND STRIPPING OF BOARD AND RAFTER, REUSE (3X) (FOUNDATION)	M2	94,53	R$ 58,55	R$ 70,46	R$ 6.660,50
3.2.6	SICOR	ED-50174	PAINTING WITH ASPHALTIC EMULSION, TWO (2) COATS	M2	77,13	R$ 28,12	R$ 33,84	R$ 2.610,05
3.3 BEAM R$ 18,997.68								
3.3.1	SICOR	ED-29582	CA-60 STEEL MESH REINFORCEMENT, WELDED TYPE Q-138, DIAMETER 04.2MM, MESH WITH DIMENSION (100X100)MM, INCLUDING SPACER, EXCLUDING CONCRETE	M2	94.53	RS 27.96	R$ 33,65	RS 3,180.66
3.3.2	SICOR	ED-49638	SUPPLY OF STRUCTURAL CONCRETE, PUMPED MIX, WITH FCK 25MPA, INCLUDING PLACING, COMPACTION AND FINISHING	M3	9,45	R$ 703.84	R$ 847,00	R$ 8.004,16
3.3.3	SICOR	ED-31573	FORMWORK AND STRIPPING FOR BEAM WITH RESIN-COATED PLYWOOD SHEET, THICKNESS 12MM, REUSE (3X), EXCLUDING BRACING	M2	94,53	R$ 68,68	R$ 82,65	R$ 7.812,86
4 PRECAST AND SEALING R$ 176,503.97								
4.1	ESTIMATE	COMP-0001	PRECAST REINFORCED CONCRETE PLATES, MANUFACTURED IN A SPECIALIZED FACTORY. THE PLATES HAVE A THICKNESS OF 3 CM AND DIMENSIONS 200X50. THE JOINTS BETWEEN THE PLATES ARE FILLED WITH CEMENT-SAND MORTAR IN A 1:3 RATIO, ENSURING SEALING AND STRUCTURAL STABILITY.	M2	380,75	R$ 300,00	R$ 361,02	RS 137,458.37
4.2	ESTIMATE	COMP-0002	PRECAST REINFORCED CONCRETE COLUMNS 1:2:2 WITH 4 STEEL BARS OF 10 MM THICKNESS	UNIT	33,00	R$ 225,00	R$ 270,77	R$ 8.935,25
4.3	SICOR	ED-50730	SCRAPING WITH MORTAR, RATIO 1:2:3 (CEMENT, SAND AND GRAVEL). APPLIED WITH A SPOON. THICKNESS 5MM. INCLUDING MORTAR WITH MECHANIZED MIXING	M2	419.70	R$ 13,90	R$ 16,73	R$ 7.020.43
4.4	SICOR	ED-50761	PLASTERING WITH MORTAR, RATIO 1:2:8 (CEMENT, LIME AND SAND), THICKNESS 20MM. MANUAL APPLICATION, INCLUDING MORTAR WITH MECHANIZED MIXING, EXCLUDING SCRAPING	M2	334,02	RS 34.64	R$ 41,69	RS 13,923.88
4.5	SICOR	ED-50732	POINTING WITH MORTAR, RATIO 1:6 (CEMENT AND SAND), THICKNESS 20MM. MANUAL APPLICATION, INCLUDING MORTAR WITH MECHANIZED MIXING, EXCLUDING SCRAPING	M2	85,68	RS 32.97	R$ 39,68	R$ 3.399,45
4.6	SICO	ED-99	BEAM OR COUNTERBEAM IN STRUCTURAL CONCRETE FOR SPANS OVER 150CM, MIXED	M2	1,63	R$ 2.93	R$ 3.5	R$ 5.766,

	R	06	ON SITE WITH A CONCRETE MIXER, "A" CONTROL, WITH FCK 20 MPA, CAST IN PLACE, INCLUDING REINFORCEMENT			9,83	37,79	60

After assembly, the walls are coated with scratch coat and finish coat, both applied with mortar mixes 1:2:3 and 1:2:6, respectively, ensuring a high-quality finish. For floor coating services, initially, a rough underlayment is applied with a 1:3 mortar mix (cement and sand), with a thickness of 20 mm. This process is mechanized, ensuring uniformity and speed in execution. Next, the floor coating is done with satin-glazed porcelain tiles, with 45x45 cm pieces, high quality (extra standard) and rectified edge, ensuring a precise finish. The installation uses industrialized mortar, which ensures greater adhesion and durability, in addition to grouting for the final finish.

Complementing the floor, satin-glazed porcelain baseboards, with a height of 10cm, are installed with industrialized mortar, also with grouting. For the thresholds, common white marble with a thickness of 2cm is used, with a polished finish, ensuring an elegant transition between environments. The budget for this coating phase is shown in Table 15.

Table 15: Budget Spreadsheet Precast (item 5).

5	COATING - EXTERNAL AND INTERNAL			R$ 40.887,94				
5.1	SIC OR	ED-50 753	COATING WITH PORCELAIN TILE APPLIED ON FLOOR, GLAZED ACETINATED FINISH. INTERNAL/EXTERNAL ENVIRONMENT, EXTRA STANDARD. RECTIFIED EDGE, PIECE DIMENSION (45X45CM), INSTALLATION WITH INDUSTRIALIZED MORTAR, INCLUDING GROUTING	M2	147,0 0	R$ 146,8 3	R$ 176, 70	R$ 25,974, 20
5.2	SIC OR	ED-50 566	FLOOR BASE WITH MORTAR, MIX 1:3 (CEMENT AND SAND), THICKNESS 20MM, INCLUDING MORTAR WITH MECHANIZED PREPARATION	M2	147,0 0	R$ 35,74	R$ 43.0 1	R$ 6,322,4 0
5.3	SIC OR	ED-90 81	COATING WITH CERAMIC APPLIED ON WALL, GLAZED FINISH. INTERNAL/EXTERNAL ENVIRONMENT. EXTRA STANDARD. PIECE DIMENSION UP TO 2025 CM2. PEI III. INSTALLATION WITH INDUSTRIALIZED MORTAR. INCLUDING GROUTING	M2	85.68	RS 70.63	R$ 85,0 0	RS 7,282.47
5.4	SIC OR	ED-51 002	GRANITE THRESHOLD, COLOR CINZA ANDORINHA, THICKNESS 2CM, POLISHED FINISH, INSTALLATION WITH INDUSTRIALIZED MORTAR, INCLUDING GROUTING	M2	3,55	R$ 306,3 8	R$ 368, 70	RS 1,308.88

For the slab and roof, a precast slab with 12 cm polystyrene filling is used, consisting of 4 cm of topping and 8cm of polystyrene for insulation. The concrete used for the topping is prepared on-site, with a strength of 25 MPa. The roof is composed of flat-type ceramic tiles, fixed on a Paraju wood batten, with a ridge made of 1:2:9 mortar, ensuring a well-insulated and resistant roof. The ceiling is covered with gypsum, applied manually, with a troweled finish, as per Table 16.

Table 16: Precast Budget Spreadsheet (item 6).

6	SLAB COVERAGE			A$ 62.093.72				
6.1	BUD GET	COMP-0 003	PRECAST SLAB WITH ISOFORTE EPS FILLING, THICKNESS 12 CM (4 CM COVERING AND 8 CM EPS), WITH PRE-FABRICATED BEAMS	M2	102,89	R$ 95,00	R$ 114 ,32	R$ 11.762, 69
6.2	SICO R	ED-4842 0	COLONIAL FLAT CERAMIC ROOF TILE COVERAGE, 24 UNITS/SQM	M2	147,00	RS 109.43	R$ 131 ,69	R$ 19.358, 15
6.3	SICO R	ED-1963 3	METAL SHORING FOR REINFORCED CONCRETE SLAB AND BEAM, TYPE "A", HEIGHT FROM (200 TO 310) CM, INCLUDING STRIPPING, ASSEMBLY, DISASSEMBLY AND LOADING.	M2XMO NTH	147,00	R$ 18,56	R$ 22, 34	R$ 3.283,2 6
6.4	SICO R	ED-4840 6	BEDDING OF THE LAST ROW OF CERAMIC ROOF TILES WITH CEMENT MORTAR, HYDRATED LIME AND UNSCREENED SAND, IN THE RATIO 1:2:9	M	28,00	R$ 15,63	R$ 18, 81	R$ 526,66
6.5	SICO R	ED-4840 7	WOODEN LATTICEWORK IN PARAJU OR EQUIVALENT, FOR CERAMIC OR CONCRETE ROOF TILES, EXCLUDING TILES	M	147,00	R$ 127,7 0	R$ 153 ,67	R$ 22.590, 10
6.6	SICO R	ED-9066	GYPSUM CEILING COATING. THICKNESS 5MM, MANUAL APPLICATION, INCLUDING SMOOTH FINISH	M2	147,00	R$ 25,85	R$ 31, 11	R$ 4.572,8 6

Regarding the frames (item 7), it includes the installation of a steel or iron metal grating, and wooden doors, following the specified dimensions, already prepared for painting or varnishing. Aluminum windows are installed with 4 mm glass and anodized finishing profiles.

In the plumbing installations (item 8), rigid PVC piping is used for sewage and cold water, with appropriate connections for different diameters. The 1,000L polyethylene water tank includes all necessary accessories, such as a float and cleaning pipes.

In sanitary ware and metals (item 9), the highlights are the metal faucets with a movable spout and aerator, as well as white marble countertops and built-in stainless steel and ceramic sinks. Therefore, items 7, 8, and 9 are highlighted in Table 17.

Table 17: Precast Budget Spreadsheet (items 7, 8 and 9).

7 SQUADS R$ 21,678.97								
7.1	SICO R	ED-50 982	GATE IN GALVANIZED STEEL SHEET, LAMBRIL TYPE, THICKNESS 1.25MM (GSG-18), WITH FRAME IN STEEL TUBE (50X30)MM, THICKNESS 1.25MM, EXCLUDING PADLOCK AND PAINT	M2	12,43	R$ 408 ,36	R$ 491, 42	R$ 6.108,3 6
7.2	SICO R	ED-49 602	COMPLETE WOODEN DOOR, DIMENSION (80X210)CM, OPENING TYPE, ONE (1) LEAF, NATURAL FINISH FOR PAINT/VARNISH, BOARD/SHUTTER TYPE. INCLUDING FRAME, HINGES AND HARDWARE, EXCLUDING PAINT/VARNISH	UN	5,00	R$ 994 .19	R$ 1.19 6,41	R$ 5.982,0 4
7.3	SICO R	ED-29 484	ALUMINUM SLIDING WINDOW WITH 2 LEAVES. 25/SUPREMA LINE, NATURAL ANODIZED FINISH, INCLUDING PROFILES, 4MM GLASS AND INSTALLATION, EXCLUDING HARDWARE FOR ALUMINUM SLIDING WINDOW	M2	9,28	R$ 858 ,61	R$ 1.03 3,25	R$ 9.588,5 7
8 PLUMBING INSTALLATIONS RS 17,786.23								
8.1	SICO R	ED-50 105	SUPPLY AND INSTALLATION OF RIGID PVC PIPE. SMOOTH SEWAGE COLLECTOR (JEI), DN 100 MM (4"), INCLUDING CONNECTIONS	M	150,00	R$ 48, 33	R$ 58,16	R$ 8.724,0 5
8.2	SICO R	ED-50 034	SUPPLY AND INSTALLATION OF RIGID PVC PIPE. SEWAGE. PB - STANDARD SERIES, DN 40MM (1 1/2"), INCLUDING CONNECTIONS	M	30,00	R$ 21, 78	R$ 26,21	R$ 786,30
8.3	SICO R	ED-50 022	SUPPLY AND INSTALLATION OF WELDABLE RIGID PVC PIPE. COLD WATER, DN 50 MM (1 1/2"), INCLUDING CONNECTIONS	M	100,00	R$ 45, 19	R$ 54,38	R$ 5.438,1 6
8.4	SICO R	ED-50 019	SUPPLY AND INSTALLATION OF WELDABLE RIGID PVC PIPE, COLD WATER. DN 25 MM (3/4"). INCLUDING CONNECTIONS	M	60,00	RS 24.46	R$ 29,44	R$ 1,766,1 1

8.5	SICOR	ED-49936	POLYETHYLENE WATER TANK. CAPACITY 1,000L INCLUDING LID. FLOAT TAP. OVERFLOW. CLEANING TUBE AND ACCESSORIES. EXCLUDING WATER INLET/OUTLET PIPING	UN	1,00	R$ 890.48	R$ 1.071,60	RS 1,071.60
9	CERAMIC FIXTURES R$ 7,182.50							
9.1	SICOR	ED-50324	METALLIC FAUCET FOR SINK, MOVABLE SPOUT, 1/4 TURN OPENING. CHROME FINISH, WITH AERATOR, COUNTERTOP APPLICATION, INCLUDING FLEXIBLE METALLIC CONNECTION, SUPPLY AND INSTALLATION	UN	6,00	R$ 164.30	R$ 197,72	A$ 1.186.31
9.2	SICOR	ED-50296	CONVENTIONAL CERAMIC TOILET BOWL (VASO), WHITE COLOR, INCLUDING FIXING/SEALING ACCESSORIES, SUPPLY, INSTALLATION AND CAULKING, EXCLUDING FLUSH VALVE AND CONNECTION TUBE	UN	2,00	R$ 327,10	R$ 393,63	R$ 787.26
9.3	SICOR	ED-48345	WHITE MARBLE COUNTERTOP, THICKNESS 3 CM. SUPPORTED ON 20 X 30 MM METALON CONSOLE	M2	5.06	R$ 525.97	R$ 632.95	RS 3,202.74
9.4	SICOR	ED-50278	UNDERMOUNT STAINLESS STEEL SINK, AISI 304, SINK APPLICATION (560X330X115MM). QUANTITY 2. INSTALLATION ON COUNTERTOP. INCLUDING CHROME-FINISHED METAL DRAIN VALVE. CHROME-FINISHED METAL CUP-TYPE TRAP. SUPPLY AND INSTALLATION	UN	2,00	R$ 489.08	R$ 588.56	RS 1,177.12
9.5	SICOR	ED-50279	WHITE UNDERMOUNT CERAMIC SINK, OVAL SHAPE, INCLUDING CHROME-FINISHED METAL DRAIN VALVE, CHROME-FINISHED METAL CUP-TYPE TRAP, SUPPLY AND INSTALLATION	UN	2,00	R$ 344,47	R$ 414,54	R$ 829,07

For electrical installations, the power supply follows the CEMIG standard, with an installed load of up to 10kW, including a pole, meter box and circuit breakers, and grounding for electrical safety. Regarding the distribution board and electrical installation, the project includes a board for 36 modules with a 100 A busbar, which distributes electricity throughout the building. For switches and sockets, standardized 10A/250V sets are used, with options for single switches and three-pole sockets, always accompanied by supports, modules and plates.

The cables used are flexible copper, with special halogen-free and flame-retardant insulation, with cross-sections ranging from 1,5 mm^2 to 35 mm^2 for different circuits and power demands. System protection is ensured by bipolar and monopolar circuit breakers, with varying rated capacities (10A, 32A and 50A). As for lighting, there are half-moon lamp holders for LED bulbs, as well as commercial luminaires for LED tube bulbs, providing an efficient and modern internal solution.

The execution of electrical and plumbing installations in precast construction has a major difference compared to the conventional masonry method, since the structures are already manufactured with pipe routing in mind, which ensures lower economic, time and environmental impact, as structural cuts are avoided. The electrical stage is shown in Table 18, with its unit and total costs.

Table 18: Precast Budget Spreadsheet (item 10).

10			ELECTRICAL INSTALLATIONS	R$ 20.752,34					
10.1	SICOR	ED-20579	AERIAL POWER ENTRY, TYPE B1, CEMIG STANDARD, INSTALLED LOAD UP TO 10KW, SINGLE-PHASE, WITH UNDERGROUND OUTLET, INCLUDING POLE, METER BOX, CIRCUIT BREAKER, BUSBAR, GROUNDING AND ACCESSORIES	UN	1,00	R$ 2.966,14	R$ 3.569,45	R$	3.569,45
10.2	SICOR	ED-49502	DISTRIBUTION PANEL FOR 36 MODULES WITH 100 A BUSBAR	UN	1,00	R$ 511,05	R$ 615,00	R$	615,00
10.3	SICOR	ED-15733	SET OF ONE (1) SINGLE SWITCH, CURRENT 10A, VOLTAGE 250V, (10A-250V), WITH 4"X2" PLATE FOR ONE (1) POSITION, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	UN	3,00	RS 25.87	R$ 31,13	R$	93,40
10.4	SICOR	ED-15765	SET OF ONE (1) SINGLE SWITCH, CURRENT 10A, VOLTAGE 250V, (10A-250V) AND ONE (1) STANDARD SOCKET, THREE (3) POLES, CURRENT 10A, VOLTAGE 250V, (2P+T/10A-250V), WITH 4"X2" PLATE FOR TWO (2) POSITIONS, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	UN	2,00	R$ 40,37	R$ 48,58	R$	97,16
10.5	SICOR	ED-15771	SET OF TWO (2) SINGLE SWITCHES, CURRENT 10A, VOLTAGE 250V, (10A-250V) AND ONE (1) STANDARD SOCKET, THREE (3) POLES, CURRENT 10A, VOLTAGE 250V, (2P+T/10A-250V), WITH 4"X2" PLATE FOR THREE (3) POSITIONS, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	UN	1,00	R$ 55.09	R$ 66.30	R$	66,30
10.6	SICOR	ED-15748	SET OF ONE (1) STANDARD SOCKET, THREE (3) POLES, CURRENT 10A, VOLTAGE 250V, (2P+T/10A-250V), WITH 4"X2" PLATE FOR ONE (1) POSITION, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	UN	27,00	RS 26.57	R$ 31.97	R$	863.31
10.7	SICOR	ED-15789	SET OF TWO (2) STANDARD SOCKETS, THREE (3) POLES, CURRENT 10A, VOLTAGE 250V, (2P+T/10A-250V), WITH 4"X2" PLATE FOR ONE (1) POSITION, INCLUDING	UN	7,00	R$ 19,88	R$ 23,92	R$	167,47
10.8	SICOR	ED-15743	SET OF ONE (1) SINGLE SWITCH, CURRENT 10A, VOLTAGE 250V, (10A-250V) AND ONE (1) STANDARD SOCKET, THREE (3) POLES, CURRENT 10A, INCLUDING SUPPLY, INSTALLATION, SUPPORT, MODULE AND PLATE	M	4,00	R$ 41,87	R$ 50,39	R$	201,55
10.9	SICOR	ED-48946	FLEXIBLE COPPER CABLE, CLASS 5, INSULATION TYPE LSHF/ATOX, NON-HALOGENATED, FLAME-RETARDANT, THERMOPLASTIC, SINGLE-CORE, CROSS-SECTION 1.5 MM², 70°C, 450/750V	M	300,00	R$ 2,91	R$ 3,50	R$	1.050,57
10.10	SICOR	ED-48951	FLEXIBLE COPPER CABLE, CLASS 5, INSULATION TYPE LSHF/ATOX, NON-HALOGENATED, FLAME-RETARDANT, THERMOPLASTIC, SINGLE-CORE, CROSS-SECTION 2.5 MM², 70°C, 450/750V	M	400,00	R$ 3,99	R$ 4.80	R$	1.920.63
10.11	SICOR	ED-48961	FLEXIBLE COPPER CABLE, CLASS 5, INSULATION TYPE LSHF/ATOX, NON-HALOGENATED, FLAME-RETARDANT, THERMOPLASTIC, SINGLE-CORE, CROSS-SECTION 6 MM², 70°C, 450/750V	M	100,00	R$ 7,88	R$ 9,48	R$	948,28
10.12	SICOR	ED-48981	FLEXIBLE COPPER CABLE, CLASS 5. INSULATION TYPE LSHF/ ATOX, NON-HALOGENATED, FLAME-RETARDANT, THERMOPLASTIC, UNIPOLAR, CROSS-SECTION 35 MM², 70°C, 450/750V	M	100.00	RS 36.57	R$ 44.01	R$	4.400,83
10.13	SICOR	ED-34473	BIPOLAR CIRCUIT BREAKER, DIN TYPE, NOMINAL CURRENT 10A. SUPPLY AND INSTALLATION, INCLUDING BUS BAR TERMINALS	UN	3,00	RS 44.61	R$ 53,68	R$	161,05
10.14	SICOR	ED-34460	MONOPOLAR CIRCUIT BREAKER, DIN TYPE. NOMINAL CURRENT 10A. SUPPLY AND INSTALLATION, INCLUDING BUS BAR TERMINALS	UN	10,00	RS 14.79	R$ 17,80	R$	177,98
10.15	SICOR	ED-34477	BIPOLAR CIRCUIT BREAKER, DIN TYPE. NOMINAL CURRENT 50A. SUPPLY AND INSTALLATION, INCLUDING BUS BAR TERMINALS	UN	1,00	RS 46.31	R$ 55,73	R$	55,73
10.16	SICOR	ED-34479	BIPOLAR CIRCUIT BREAKER, DIN TYPE. NOMINAL CURRENT 50A. SUPPLY AND INSTALLATION, INCLUDING BUS BAR TERMINALS	UN	1,00	RS 47.09	R$ 56,67	R$	56,67
10.17	SICOR	ED-34475	BIPOLAR CIRCUIT BREAKER DIN 5KA. 20A	UN	3,00	RS 42.06	R$ 50.62	R$	151,85
10.18	SICOR	ED-34474	BIPOLAR CIRCUIT BREAKER DIN 5KA. 16A	UN	10.00	RS 42.09	R$ 50.65	R$	506.51
10.19	SICOR	ED-34477	BIPOLAR CIRCUIT BREAKER DIN 5KA. 32A	UN	1,00	RS 43.35	R$ 52,17	R$	52,17

10.20	SICOR	ED-34472	BIPOLAR CIRCUIT BREAKER DIN 5KA. 60A	UN	1,00	R$ 58.63	R$ 70,56	R$	70.56
10.21	SICOR	ED-13345	WALL LIGHT, FULL HALF-MOON TYPE. DIAMETER 25 CM. FOR ONE (1) LED BULB. POWER 15W. BULB A65. SUPPLY AND INSTALLATION. INCLUDING BASE AND BULB	UN	2.00	R$ 66.57	R$ 80.11	R$	160.22
10.22	SICOR	FD-13338	COMMERCIAL RECESSED OVERHEAD LIGHT, FULL TYPE. FOR TWO (2) LED TUBULAR BULBS 2X18W-OT8. COLOR TEMPERATURE 6500K. SUPPLY AND INSTALLATION, INCLUDING BASE AND BULBS	UN	19.00	R$ 191.50	R$ 230,45	RS	4.378.57
10.23	SICOR	ED-13346	WALL LIGHT, FULL HALF-MOON TYPE. DIAMETER 25 CM. FOR ONE (1) LED BULB. POWER 20W. BULB A70. SUPPLY AND INSTALLATION. INCLUDING BASE AND BULB	UN	11.00	R$ 74.57	R$ 89.74	R$	987.11

In the painting phase, walls and ceilings will be treated with acrylic paint, ensuring uniform coverage and high durability. Surface preparation includes the use of acrylic sealer and joint compound to ensure adhesion and a high-quality final finish.

Finally, the final cleaning will be carried out carefully, removing all construction debris, so that the delivery meets the expected quality standard. All materials and processes follow the criteria established by current standards, such as ABNT NBR 15575-1 (2024) for residential buildings, ensuring safety, comfort, and durability for the project. Thus, the two final phases are shown in Table 19.

Table 19: Precast Budget Spreadsheet (items 11 and 12).

11			PAINT	R$ 21.279.83				
11.1	SICOR	ED-50451	ACRYLIC PAINT ON WALL, TWO (2) COATS, EXCLUDING ACRYLIC SEALER AND ACRYLIC FILLER/RUNNER (PVA)	M2	334,02	R$ 16,47	R$ 19,82	R$ 6.620,28
11.2	SICOR	ED-50452	ACRYLIC PAINT ON CEILING, TWO (2) COATS, EXCLUDING ACRYLIC SEALER AND ACRYLIC FILLER/RUNNER (PVA)	M2	147,00	RS 18.11	R$ 21,79	R$ 3.203,66
11.3	SICOR	ED-50476	FILLING ON CEILING WITH ACRYLIC FILLER, TWO (2) COATS, INCLUDING SANDING FOR PAINTING	M2	147,00	R$ 36,40	R$ 43,80	R$ 6.439,15
11.4	SICOR	ED-50514	PREPARATION FOR FILLING OR PAINTING (LATEX/ACRYLIC) ON WALL, INCLUDING ONE (1) COAT OF ACRYLIC SEALER	M2	199,56	20,89	R$ 25,14	R$ 5.016,74
12			FINAL CLEANING	R$ 1.629,69				
12.1	SICOR	ED-50266	FINAL CLEANING FOR HANDOVER OF THE WORK	M2	184.00	R$ 7,36	RS 8.86	R$ 1.629,69

From the sum of the stages, it is possible to obtain the total value of the work for the entire execution in precast concrete, which is R$416,085.28. Thus, with the budget for this construction method finalized, the construction schedule is also drawn up.

3.4 Precast Construction Schedule Gantt Chart

The Gantt chart is an essential tool in project management, especially in civil construction works, as it enables clear and chronological visualization of activities. It assists in organizing and monitoring work progress, allowing coordination between different teams and sectors, in addition to enabling adjustments to deadlines and resource allocation. Its use ensures that the construction schedule is followed more efficiently, minimizing the risk of delays and optimizing execution time.

In the context of the work carried out by Liu do Pré-Moldado, which uses precast elements for construction, the use of Gantt chart premises was crucial to ensure compliance with the established deadlines. It was stipulated that the work began on October 21, 2024, with an expected delivery date of December 30, 2024, totaling 70 calendar days. This period was fundamental for the completion of the structure, allowing the company to ensure greater efficiency and speed in execution, thanks to the use of precast elements. This schedule is shown in Table 20.

Table 20: Chart with Gantt premises for precast execution.

Service	Weeks									
	1	2	3	4	5	6	7	8	9	10
Make the pre-molded material in the factory										
Foundation and wall sealing										
Slab										
Roof										
Plaster										
Internal wall and floor covering										
Joinery										
Plumbing installations										
Electrical installations										
Sanitary ware										
External covering										
Painting										
Final Cleaning @ @										

From the graph, it is possible to perceive the difference regarding execution in masonry, since the walling phase using precast elements is no longer considered one of the longest stages, as the panels arrive pre-fabricated at the construction site and only need to be fitted and the joints filled with mortar.

It is important to highlight that the company in question also provides precast assembly and construction services.

Furthermore, when considering the process of building prefabricated houses, it is possible to observe that, without finishes, the delivery time can be reduced to 15 to 20 days. However, when comparing a house with all finishes completed, the execution time increases as more stages are carried out, but results in a higher quality final product for the client.

With the budget and construction time data obtained, they are analyzed according to the stages of each execution, through the creation of graphs that allow for a simplified visualization of the construction methods.

3.5 Comparison Between Construction Methods

The comparison between the two construction methods, masonry walling and precast concrete, is made using the defined budget data and construction time. It is important to note that dividing the entire construction into stages is crucial, as in any building, construction methods can be mixed, that is, using one method in one phase and another method in another phase. Additionally, it is possible to determine which part of the construction is responsible for consuming more time and expenses. For this, graphs are created for each construction system using Excel.

3.5.1 Budget Graphs

The cost graph is developed using a bar graph that shows expenses in each stage and an S-curve that will delimit accumulated expenses. Since the constructions were based on systems from different companies, and their analysis methods are also different, the stages were divided to be analyzed individually.

For the elaboration of the graph for the masonry walling construction, the stages were divided into site preparation (items 1 and 2), concrete structures (item 3), walling (item 4), roofing (item 5), plumbing installations (item 7), electrical installations (item 6), fixtures and metals (item 8), cladding and flooring (item 9), painting and joinery (items 10 and 11), final cleaning (item 12), aiming for an equal division for better comparison. Thus, Figure 2 shows the stage costs through bars, reaching the previously found total of R$377,083.81 as idealized by the S-curve.

Figure 2: Expense values - Sealing masonry.

As for the elaboration of the graph for the precast concrete construction, the stages were divided in the same way, but corresponding to different items and sub-items, as can be seen according to the following phases: site preparation (items 1 and 2), concrete structures (item 3 and sub-items 4.2, 4.6, 6.1 and 6.3), walling (sub-items 4.1, 4.3, 4.4 and 4.5), roofing (sub-items 6.2, 6.4, 6.5 and 6.6), plumbing installations (item 8), electrical installations (item 10), fixtures and metals (item 9), cladding and flooring (item 5), painting and joinery (items 7 and 11), and final cleaning (item 12). In this way, Figure 3 shows the expenses per stage in bars and the accumulated total through the S-curve, which is R$416,085.28.

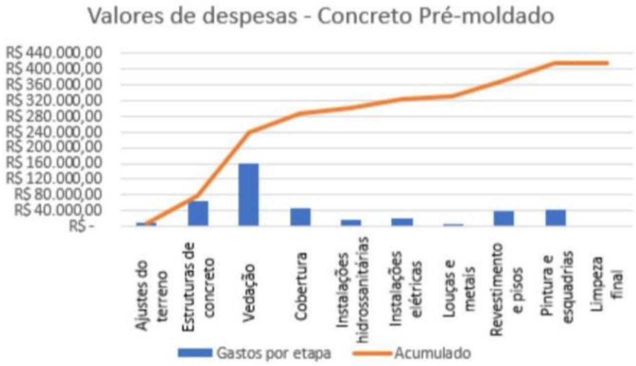

Figure 3: Expense values - Pre-cast.

By analyzing the graphs, it is possible to perceive the cost differences between the stages of each method in a more simplified way. The stage that generates the greatest discrepancy is the walling, which is carried out with different materials, and thus, conventional masonry has an expense of R$101,103.39 less than precast concrete. These data show that even though masonry uses a greater number of forms in this phase, leading to higher labor and material costs, the high value of precast panels still stands out.

Another point to highlight is the concrete structures stage, which generates a cost difference of R$61,688.56, where masonry construction exceeds prefabricated construction. This discrepancy is due to two factors: the first relates to the use of forms, where the precast company reuses its own forms extensively, which results in less time spent on the construction site, that is, a reduction in the costs of this material and in the labor required to set the forms. Additionally, another aspect to consider in this phase is the different execution methods used by each company, such as the different assembly of columns. Thus, the difference in the final cost between the two constructions can be shown. Conventional masonry construction ensured a lower expense of R$39,001.97 compared to the same building but executed with precast concrete.

The study of the costs of each construction stage is essential for choosing the techniques to be used. By comparing the two expense graphs, it can be stated that, considering economic factors, the walling stage should be executed using conventional masonry and the concrete structures could have been carried out using precast to reduce construction costs.

Analyzing the budget issue is essential to choose the best construction method, but this is not the only aspect that should be explored, as execution time can also be longer, which does not result in a cost-benefit for the builder or owner. Therefore, a study on the completion time of each construction stage is conducted.

3.5.2 Construction time in graph

Execution time is considered in relation to the work to be performed and the amount of labor, as well as its efficiency. Therefore, for each construction method, the stages were analyzed and their completion deadlines were defined.

That said, the construction time graphs were built in Excel using column charts and were divided into distinct stages following the characteristics of a Gantt chart, considering that the activities are carried out in different ways in the two construction methods.

Figure 4 shows the time graph for the masonry construction, which was subdivided into stages according to the Gantt-style chart, taking a total of 16 months.

Fonte: dos autores, 2024.

Figure 4: Work time - Sealing masonry.

As for the elaboration of the graph with construction time for each stage considering precast concrete execution, the phases differ, since each method is produced with different activities and materials, resulting in Figure 5.

Figura 5: Tempo de obra - Pre-moldado.

With the elaborated graphs, it is possible to perceive that the time spent on the stages is not proportional to their expenses. It is essential to note in traditional masonry that the highest costs are in foundations, concrete structures, and walling itself, and these stages are executed in half the time of floor and wall finishing. Furthermore, in precast construction, the highest costs are in the concrete structures and walling stages, which correspond to 50% of the time spent on plastering and internal finishing.

4. Conclusions

Aiming to compare the total costs of residential projects, analyzing the financial efficiency and construction time of conventional masonry and precast construction methods in a specific project, the study involves a literature review and the collection of detailed budgetary data from two companies: one that uses precast elements and another that works with masonry. In addition to costs, the study also examines construction execution time, providing a clear view of expenses and the duration of construction stages.

The methodology employed in this work initially adopted an explanatory approach, which highlighted relevant aspects to be considered in the choice of construction method. This approach provided a comprehensive view on the topic of conventional masonry, precast concrete, and budgeting. Furthermore, an exploratory approach was carried out through the analysis of a real construction project, in which data were examined and costs were compared using the budget of an alternative construction method, specifically precast construction.

Thus, the comparative cost analysis between precast and conventional masonry constructions revealed significant findings that can guide strategic decisions in the construction industry. In the context of this study, in real cases where construction time must be reduced, precast concrete is an excellent option for building; however, in buildings that can have a longer execution period, considering conventional masonry is a viable alternative since it presented lower costs in this popular standard housing. Moreover, it is essential to consider not only these values as a whole but also to break down costs and construction time into phases, ensuring a detailed analysis that leads to an appropriate choice.

Throughout this work, it was possible to observe that both methods have distinct characteristics that influence not only initial costs but also the long-term economic viability of the buildings. Precast constructions stand out for the speed of construction execution, allowing a considerable reduction in construction time. This speed not only accelerates the return on investment but also minimizes indirect costs related to the construction site and labor, making it an attractive alternative in projects with tight deadlines. Another aspect is that precast structures generally have greater strength and less need for maintenance over time, reflecting in significant savings in operational costs.

On the other hand, conventional masonry has a longer execution time that can result in additional costs, one of which is the use of formwork, not only with its cost but also the time spent on assembly, generating more labor, in addition to negatively impacting the schedule. The generation of debris and consequent rework are also factors that increase the construction period and further contribute to discussions on the topic of sustainability and waste generation in this sector. Furthermore, this method may require more frequent maintenance during the building's lifespan, especially if not well planned and executed, as in that case, they become more susceptible to structural problems and deterioration, which should be considered in cost analysis.

In this way, these results are essential for choosing the construction method to be used, as they show which stages are more advantageous within the analyzed techniques and contribute to the conclusion that although conventional masonry is the majority method in the country, it may not be the best choice depending on the circumstances of the project. Based on the results obtained, it is evident that the choice between precast construction and conventional masonry should consider not only immediate costs but also factors such as delivery times, labor availability, and future maintenance expectations. In short, this work concludes that there is no absolute superior method; the ideal choice depends on the specifics of each project. Thus, it is recommended that investors and industry professionals adopt a holistic approach when evaluating available options, especially regarding the analysis of each construction stage, considering that the method chosen for one phase may differ from that chosen for another part.

Research is essential to ground and enhance the study before selecting the construction method to be adopted in the building. Therefore, the present work has a significant impact on civil construction, as it provides support for builders, engineers, and project owners in decision-making, as well as in choosing appropriate materials and construction techniques for each stage. However, a limiting factor in the study is that precast construction is relatively recent compared to other construction methods, especially in relation to conventional masonry. As a result, there is a scarcity of studies addressing the specific properties of this method. Additionally, an aspect that limits the generalization of the results obtained is the diversity of ways in which precast can be implemented, not being restricted to the concrete model alone. Therefore, it is not possible to predict results applicable to all existing prefabricated construction methods.

It is recommended for future research to further explore the environmental and sustainable implications of construction methods, contributing to a more responsible and innovative civil construction sector. In this context, quantifying the waste generated in conventional masonry works and precast concrete works is essential for a more comprehensive assessment of the sustainability of each of these construction methods; for this, the number of dumpsters required for each type of work can be used as a comparative unit of measurement. Considering that waste generation in civil construction is a widely discussed topic with significant figures, it is important to emphasize that sustainability-related issues can influence companies' decisions in choosing the construction method adopted, as this subject has gained increasing relevance in contemporary approaches. Furthermore, it is interesting to compare these construction methods in future non-residential works, such as commercial and industrial ones, to verify economic and time viability in different contexts.

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